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Modeling and Simulation Network Data Standards

Technical Memorandum

TRADOC Analysis Center
255 Sedgwick Avenue
Fort Leavenworth, KS 66027-2345

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14. ABSTRACT

This document presents the input and output data standards and formats for four simulations: Advanced Warfighting Simulation, Combined Arms Analysis Tool for the 21st Century, Joint Network Analysis Tool, and OPNET. The Architecture Integration Management Division (AIMD), the Army Materiel Systems Analysis Activity (AMSAA), the Communications-Electronics Research Development and Engineering Center (CERDEC), and the Training and Doctrine Command (TRADOC) Analysis Center (TRAC) collaborated on developing the data descriptions required to produce this document. AMSAA, CERDEC, and TRAC provided simulation input and output requirements. AIMD, with the model agency contributions, developed the organized Department of Defense Architecture Framework integrated dictionaries and built the logical data models. These data standards and formats provide a guide for data requirements in current analyses, and a baseline to develop enhancements in data transfers in future projects.

15. SUBJECT TERMS AWARS, COMBATXXI, JNAT, OPNET, network data standards, M&S

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1. Introduction.

1.1. Purpose. This technical memorandum documents the models and simulations (M&S) data standards and formats used by the Army Materiel Systems Analysis Activity (AMSAA), the Communications-Electronics Research Development and Engineering Center (CERDEC), and the Training and Doctrine Command (TRADOC) Analysis Center (TRAC). It is the culmination of the Modeling and Simulation Network Data Standards project TRAC conducted from November 2010 through September 2011.

1.2. Problem. The Army modeling and simulation (M&S) community of practice (CoP) requires the ability to share network-related data to enable use of M&S to inform decisions on network capability sets. The CoP cannot easily generate and share the necessary data because no common data standard exists for network-related data used in M&S.

1.3. Scope. This documentation addresses network-related data standards for the Advanced Warfighting Simulation (AWARS), the Combined Arms Analysis Tool for the 21st Century (COMBATXXI), the Joint Network Analysis Tool (JNAT), and OPNET, a commercial high-resolution network analysis simulation tool.

- Constraint. Project results were due to Headquarters, Department of the Army (HQDA), Office of the Chief Information Officer/G-6, and HQDA G-3/5/7, Army Modeling and Simulation Office, by September 2011.
- Limitation. The study team documented standards and formats, but not data, for AWARS, COMBATXXI, JNAT, and OPNET as used by AMSAA, CERDEC, and TRAC.
- Assumption. The standards and formats developed for the Government will be commercially applicable.

1.4. Report Organization. After this introduction, the document is organized as follows.

- Section 2 presents an overview of the four models and depicts the data flow between the models.
- Section 3 identifies the nature of the data standards developed through this effort.
- Section 4 presents findings and recommendations.
- The appendices provide the data input and output standards and definitions for each of the four models.

1.5. Summary. This project documents the input and output data standards and formats for the AWARS, COMBATXXI, JNAT and OPNET M&S. The TRADOC Architecture Integration Management Division (AIMD), AMSAA, CERDEC, and TRAC developed the data standards and formats presented in this document. As owners and users of models, AMSAA, CERDEC, and TRAC provided the simulation input and output requirements. AIMD, with the model agency contributions, developed the organized Department of Defense Architecture Framework

(DODAF) integrated dictionaries (all view (AV)-2) and built the presented logical data models (operational view (OV)-7). This document discusses the M&S, the DODAF products, and the simulation-specific data inputs and outputs. The project identified the need to create a standard nomenclature for posting and retrieving unit and equipment data among study teams and projects. As a baseline for current data requirements, the project team recommends identifying future requirements and developing a plan to capture changes to future data requirements. These data standards and formats provide a guide for data requirements in current analyses, and a baseline to develop enhancements in data transfers in future projects.

2. Simulation Summaries and Data Flow.

2.1. AWARS. AWARS is TRAC's operational-level combat simulation. TRAC uses AWARS to dynamically simulate TRADOC standard scenarios and to conduct operational analyses of concepts, doctrine, organizations, and combat systems. AWARS is a multi-sided, deterministic, expected value, discrete event simulation of combat in a joint environment representing land, air, and maritime forces. AWARS portrays a wide range of brigade combat team (BCT), division, and joint capabilities, including joint intelligence, surveillance, and reconnaissance; joint fixed-wing air operations; and naval surface fire support.

2.2. COMBATXXI. COMBATXXI is TRAC's BCT/Marine Expeditionary Force (MEF) echelon-level simulation. This analytical stochastic simulation tool evaluates weapon systems and tactics of combat operations and operations other than war. COMBATXXI is used for analysis supporting decision support, force capability, force composition, force requirements, mix assessment, system effectiveness, combat development, and model-test-model approaches.

2.3. JNAT. JNAT is a Web application that provides connectivity and network analysis capability. JNAT uses propagation models and low-fidelity network traffic flow models to estimate first-order network performance. These estimates enable quick-turn analyses to feed high-level architectural studies in which sponsors must make investment decisions, such as the number and placement of radios, including unmanned aircraft systems, satellite communication terminals, etc. The code focuses on connectivity/flow metrics that are relatively easy to compute with short turnaround time.

2.4. OPNET. OPNET is a modeling environment used to analyze the performance of various networks under varying conditions of terrain, movement, and traffic loads. OPNET models use commercial off-the-shelf network components or tailored components representing the particular communication system or network of interest.

2.5. Data Flow. Each of the four identified models and simulations relies on input from, and produces output for, other models. For example, AWARS and COMBATXXI provide operational context to the two performance models through unit-movement data inputs. The network models conduct performance analysis based on specific scenario context. JNAT and OPNET provide performance data as inputs to each of the combat models. Study teams then use the combat models to conduct operational analysis based on the specific network data inputs.

The CoP is an Army network community including the Signal Center of Excellence, TRADOC capability managers, and program managers, among others. The CoP provides network details that are specific in nature (see figure 1.)

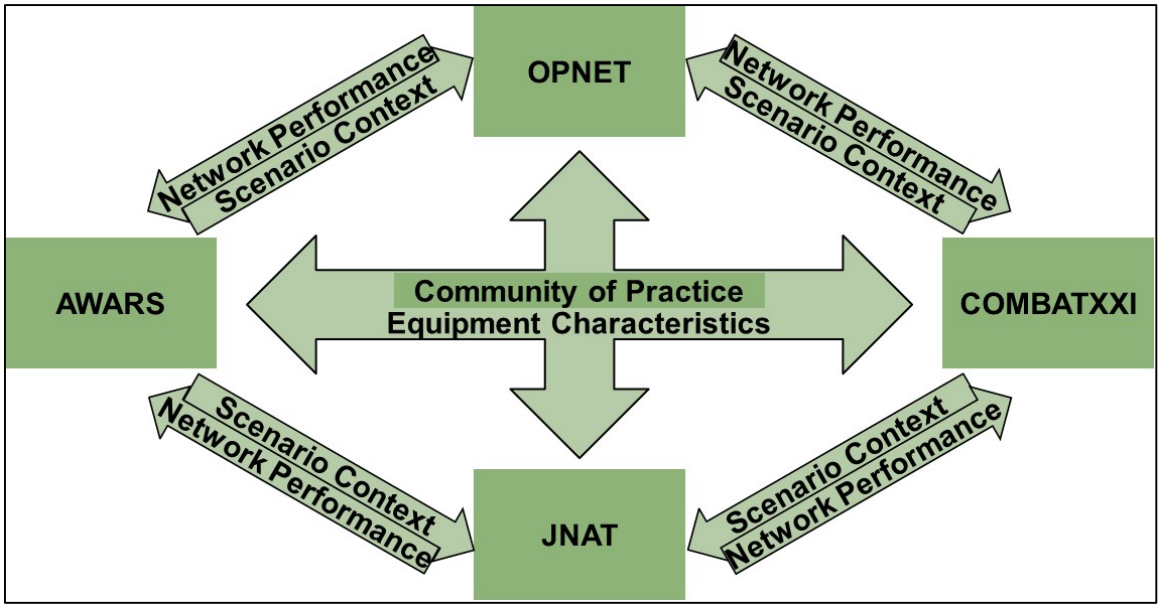

Figure 1. Data Flow Among Models.

3. Data Standards and Formats.

3.1. DODAF. The project team considered two DODAF versions to document the data inputs and outputs, while building specific supporting views. The DODAF version AIMD customarily references is version (V) 1.5; however, V2.02 is the most recently published version. Specifically, DODAF V2.02 and V1.5 were referenced in building the logical data models called the data and information viewpoint (DIV)-2 in V2.02 and the operational view (OV)-7 in V1.5. The team also built an all viewpoint (AV)-2, which is the integrated dictionary in both versions of the framework.

3.2 Logical Data Models. The study team built logical data models for each simulation considered. Logical data models are a depiction of data, data relationships, and data characteristics. In the follow-on appendices, logical data model diagrams present inputs and outputs for each model. Logical data model descriptions from the two DODAF versions follow.

- DIV-2 (V2.02). The DIV-2 is a generalized formal structure in computer science (DODAF 2.02, p. 135) documenting the data requirements and structural business process (activity) rules [DODAF V2.02, p. 135].
- OV-7 (V1.5). The OV-7 describes the structure of an architecture domain's system data types and the structural business process rules (defined in the architecture's OV) that govern the system data. It provides a definition of architecture-domain data types, their attributes or characteristics, and their interrelationships. OV-7, including the domain system's data types or entity definitions, is a key element in supporting interoperability

between architectures, since other organizations may use these definitions to determine system data compatibility. Often, different organizations may use the same entity name to mean different kinds of system data with different internal structures [DODAF V1.5, p. 3-16].

3.3 Integrated Dictionary. The study team produced integrated dictionaries for each simulation this project considered. In the follow-on appendices for each model, the integration dictionary presents data descriptions in context with other information provided about the simulation. Integrated dictionary descriptions from the two DODAF versions follow.

- AV-2 (V2.02). AV-2 is an architectural data repository with definitions of all terms used throughout the architectural data and presentations [DODAF V2.02, p. 23].
- AV-2 (V1.5). AV-2 contains definitions of terms the given architecture uses. It consists of textual definitions in the form of a glossary, a repository of architecture data, their taxonomies, and their metadata (i.e., data about architecture data), including metadata for tailored products associated with the architecture products developed ([DODAF V1.5, p. 3-16].

4. Findings and Recommendations.

4.1. Findings.

- Standard nomenclature. The use of simulation-specific and study-specific nomenclature to identify units and equipment causes analytical inefficiencies by requiring naming adjudication across agencies. Nomenclature adjudication takes CERDEC approximately 50 percent of M&S analysis time [CERDEC, p. 7].
- Data usage. Across the range of examined models and simulations, similar data types are required, but typically formatted or employed to the resolution of the model. For example, AWARS requires a predetermined maximum transmission distance for each communication device. Other models require attributes of the antenna and its working environment to calculate the maximum communication distance.

4.2. Recommendations.

- Standard nomenclature. Develop a standard nomenclature structure for units, equipment, and changes to units and organization. Each organization will be responsible for reading from and writing to the standard nomenclature for their analysis. This will improve efficiency of data transfer among the study agencies and their simulations.
- Data usage. Establish and maintain a consistent pedigree of data sources, especially when all the agencies are participating in a common project. This reinforces the overall pedigree of study data across the agencies participating in the overall effort.
- Future requirements. Identify future requirements, and develop and implement a plan to capture changes to future data requirements using this documentation as a baseline.

Appendix A. Advanced Warfighting Simulation (AWARS)

A-1. Data Inputs. AWARS is an operational-level, deterministic combat simulation requiring significant amounts of combat-related input data to produce a credible, validated division or brigade simulation. The focus of the data inputs in this document is limited to network-related data. For AWARS, direct input of network-related data required for a division or brigade representation includes task organization, communication equipment characteristics, and network performance data (figure A-1.).

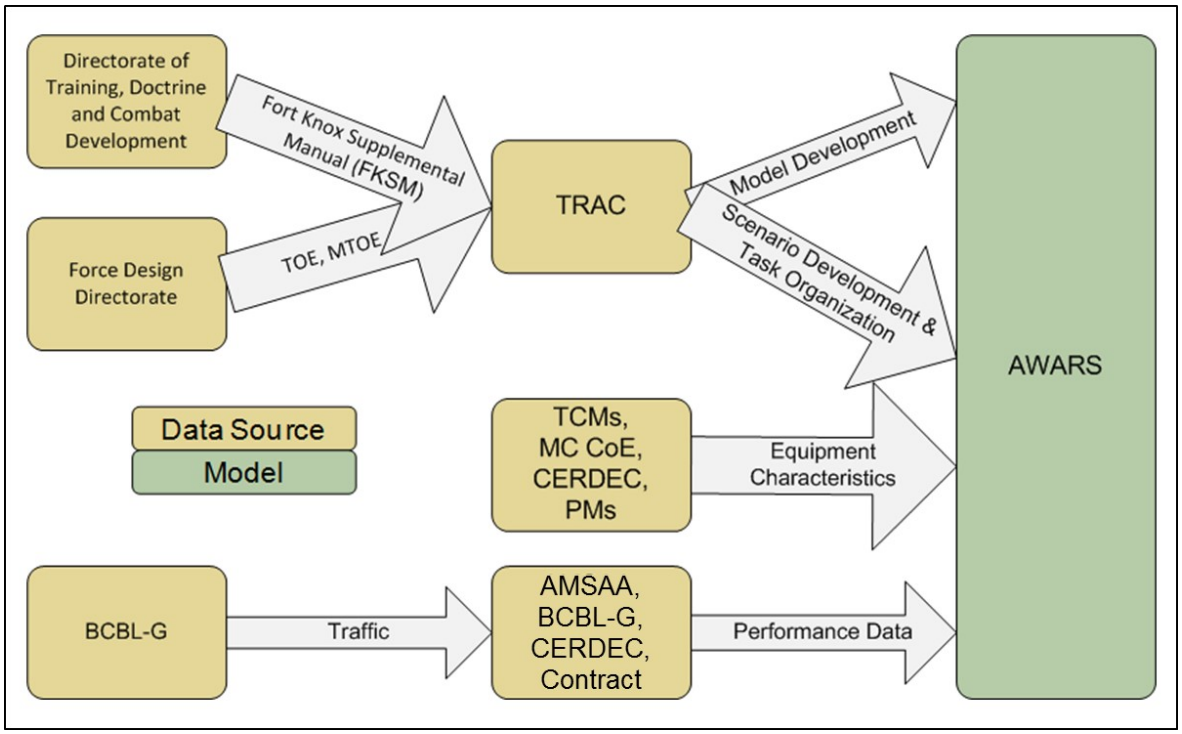

Figure A-1. General AWARS Data Inputs.

The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) maintains the model, providing in-house model development, including code development and conduct of simulations. Additionally, TRAC develops in house the Army's Defense Planning Guidance-compliant scenarios that AWARS uses. TRAC's scenarios contain data relating to task organization, standard requirements code (SRC), and scheme of maneuver. Members of the community of practice (CoP) provide equipment characteristics data for network-related equipment modeled in AWARS. These characteristics include maximum transmission range and line-of-sight requirements. A variety of Army agencies or contract organizations produce performance data.

The following two figures depict the specific AWARS inputs. Figure A-2 diagrams AWARS-specific input data that network performance analysis requires. Figure A-3 diagrams the specific data inputs for equipment.

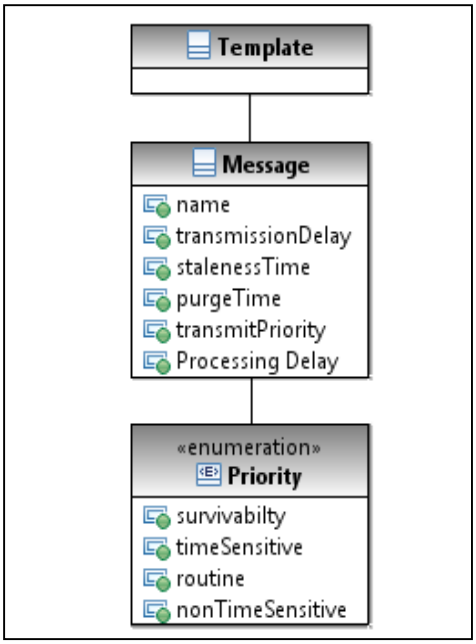

Figure A-2. AWARS Performance Data Inputs.

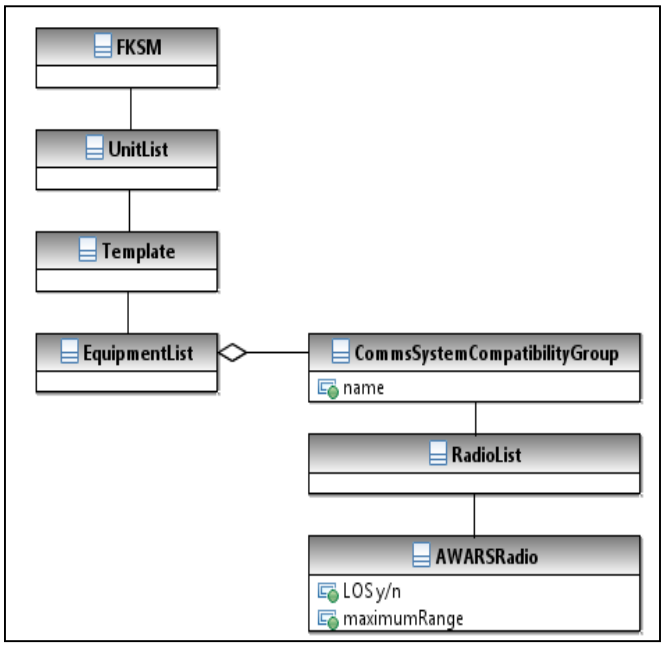

Figure A-3. AWARS Network Data Inputs.

The integrated dictionary of AWARS data inputs is provided in Table A-1.

Table A-1. AWARS Data Input Dictionary.

Input Data Element	Definition
1.0 AWARS Radio	The name of a communications device capable of transmitting information (voice, data, etc.). User defined.
1.1 Line of Sight (LOS)	A measure (Boolean, yes or no) of whether there is a requirement for an unobstructed path between two communications devices. User defined; provided by TRADOC capability manager (TCM) or project manager (PM).
1.2 Maximum Range	A measure, in kilometers (km), of the greatest distance allowable in which a piece of equipment can perform its intended function. User defined; provided by TCM or PM.
2.0 Radio List	The list of radio types for a given organization within the AWARS simulation. User defined; derived from Fort Knox Supplemental Materiel (FKSM) or alternative development.
3.0 Communications System Compatibility Group	Set of equipment in which a radio is compatible. Provided by TCM or PM.
3.1 Name	A unique text identifier of the communications system compatibility group assigned by AWARS. User defined.
4.0 Equipment List	Combat materiel assigned to an AWARS unit. User defined; derived from FKSM.
5.0 AWARS SRC	Consists of the base unit design in which specific units inherit functionality and equipment. User defined.
6.0 Unit List	Task organization of units gamed in AWARS. User defined; provided by the scenario development study team.
7.0 FKSM	Fort Knox Supplemental Materiel, reference data for force design. Provided by Ft. Knox Directorate of Training, Doctrine, and Combat Development.
8.0 Message	AWARS-defined exchange of information. User defined.
8.1 Name	Contains unique text for each message. User defined.
8.2 Transmission Delay	Aggregate time, in seconds, required for transmission of a specific AWARS message, at the transmitting unit. User defined; provided by performance analysis organization.
8.3 Staleness Time	Time elapsed, in seconds, in which the transmitted message is no longer useful if transmission is completed. User defined.
8.4 Purge Time	Time elapsed, in seconds, in which AWARS discards the message. User defined.
8.5 Transmit Priority	Priority listing of the message based on global information grid (GIG) categories: survival, time-sensitive, routine, and non-time-sensitive. User defined.
8.6 Message Priority	Priority listing of the message based on GIG categories: survival, time-sensitive, routine, and non-time-sensitive. User defined.
8.7 Processing Delay	Aggregate time required for the processing of a specific AWARS message, at the receiving unit; measured in seconds. User defined.

A-2. Data Outputs. The customary outputs other simulations require from AWARS for network analysis are unit movement profiles over time. Specifically, over time, AWARS reports unit names, orientation, locations, mass, and speed that the Joint Network Analysis Tool (JNAT) and OPNET can use. AWARS provides output data in a unit history file (see summary at figure A-4 and detailed definitions at table A-2).

Figure A-4. AWARS Output.

Table A-2. AWARS Data Output Dictionary.

Output Column	Output Data Element	Definition
1	**DD:HH:MM:SS**	AWARS-specific time stamp for the unit location in day:hour:minute:second.
2	**Unit name**	Unit naming convention AWARS uses.
3	**Mounted**	Flag indicating mounted/dismounted unit status designation.
4	**xLoc**	The x-portion of the (x,y) coordinate, designating the x direction from the origin measured in km.
5	**yLoc**	The y-portion of the (x,y) coordinate, designating the y direction from the origin measured in km.
6	**Orientation**	Direction the unit is facing, measured in degrees.
7	**Direction**	Direction of unit movement, measured in degrees.
8	**MassAuth**	AWARS maximal value describing the strength of a specific unit.
9	**MassOnHand**	AWARS' current measure of the value originally valued "massAuth." Note: "massOnHand/massAuth" calculates the unit strength; additionally, when the ratio falls below a specific ratio, AWARS purges the unit.
10	**UnitNetSpeed**	Unit speed in km per hour.
11	**Route**	Flag indicating whether unit currently has a route to next objective.
12	**DistMovedSince Last**	Distance in km from last position update.

Appendix B. Combined Arms Analysis Tool for the 21st Century (COMBATXXI)

B-1. Data Inputs. COMBATXXI is a tactical-level, brigade-and-below combat simulation requiring significant amounts of data to produce a credible, statistically significant set of stochastic tactical simulation runs. The focus of the data inputs in this document is limited to network-related data. For COMBATXXI, direct input of network-related data required for simulation includes scenario development, with task organization, equipment characteristics, and network performance data (figure B-1).

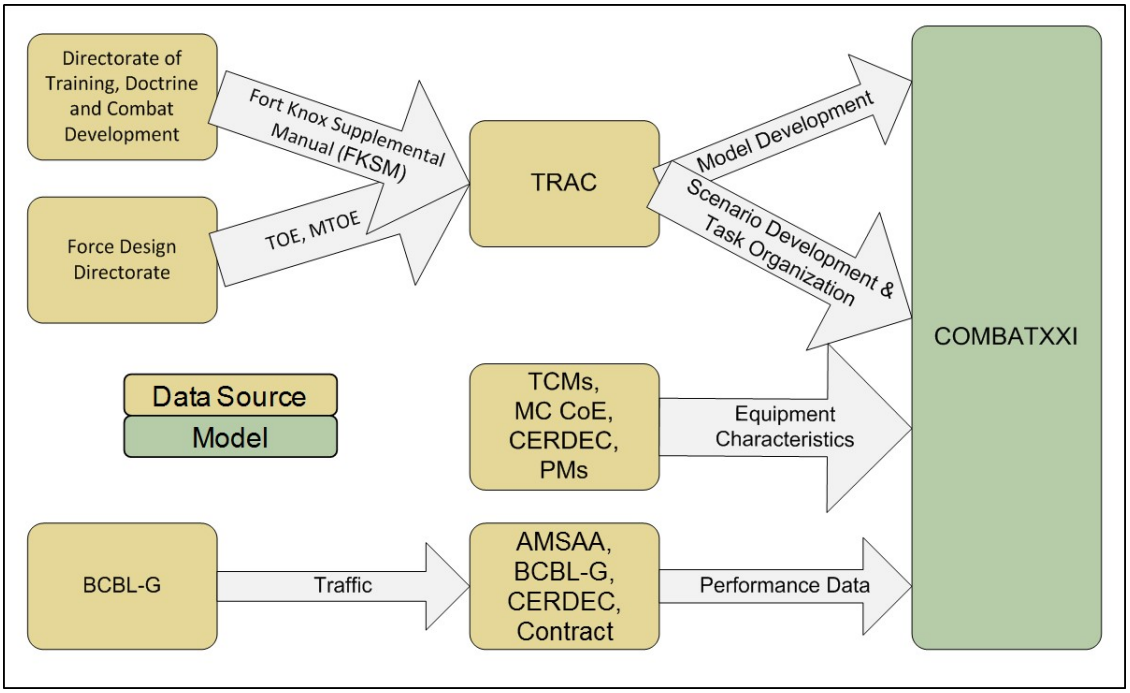

Figure B-1. General COMBATXXI Data Inputs.

The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) maintains the model, providing in-house model development, including code development and conduct of simulations. Additionally, TRAC develops the Army's Defense Planning Guidance-compliant scenarios that COMBATXXI uses. TRAC's scenarios contain data relating to task organization, table of organization and equipment (TOE), and scheme of maneuver. Community of practice (CoP) members provide equipment characteristics data for network-related equipment modeled in COMBATXXI. Equipment characteristics include, but are not limited to, operating frequency range, output power, and firmware version. Several Army agencies produce performance data. The following logical diagrams, figures B-2 and B-3, depict the required inputs for the COMBATXXI simulation.

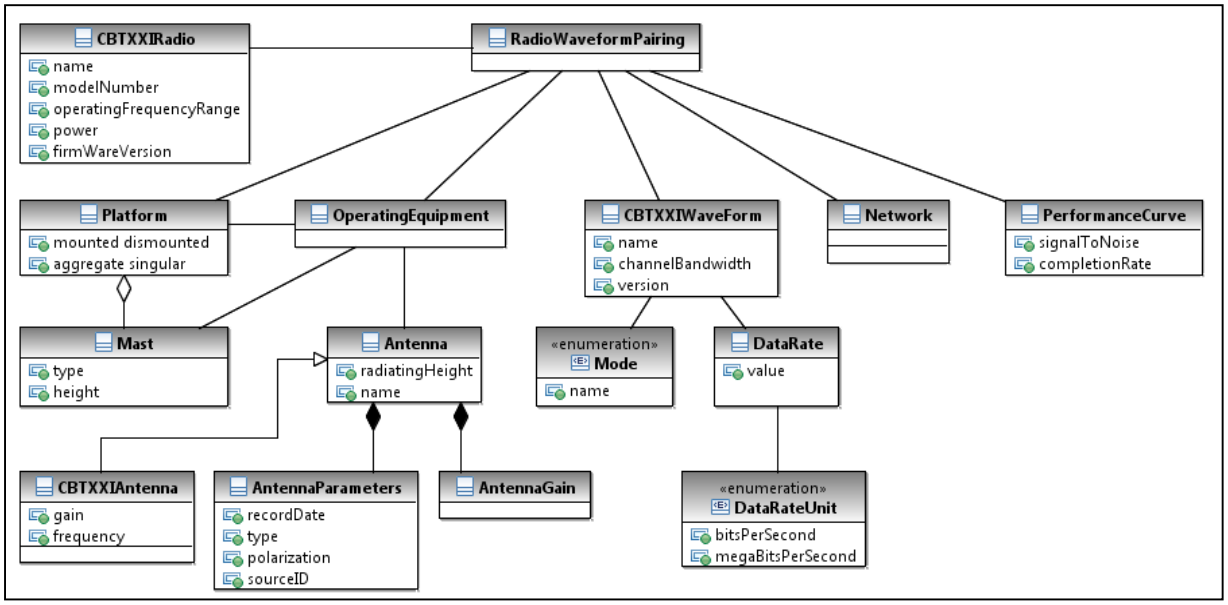

Figure B-2. COMBATXXI Performance Data Inputs.

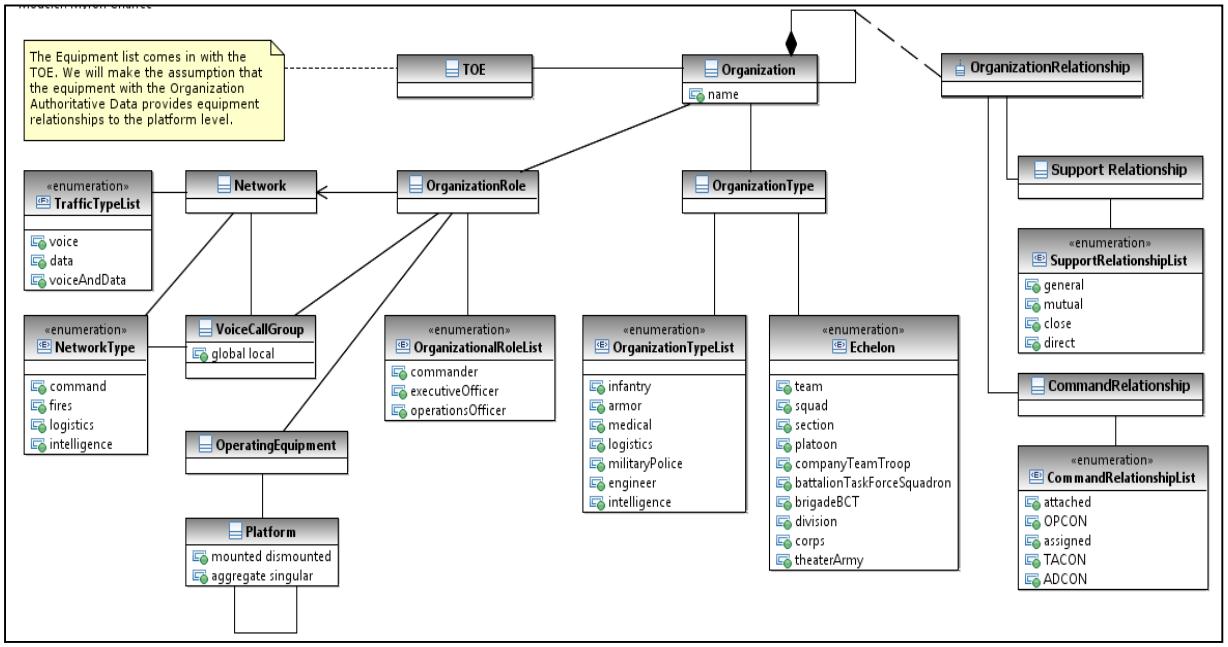

Figure B-3. COMBATXXI Network Data Inputs.

Table B-1 provides the integrated dictionary of COMBATXXI data inputs. The first four entries relate to the organizations represented in COMBATXXI. Note that every entry on the organization type list (input data element 3.0) requires a significant amount of additional input data, as defined in the table.

Table B-1. COMBATXXI Data Input Dictionary.

Input Data Element	Definition
1.0 Organization	A collection of people and equipment designed to accomplish an identified set of capabilities, for example, 1st Battalion, 22nd Infantry. User defined.
1.1 Name	The unique identifier of an organization. User defined.
2.0 Organization Type	This is a name indicator field. This indictor designates the template type for a particular group of organizations possessing the same set of capabilities; e.g., heavy brigade combat team (BCT). User defined.
3.0 Organization Type List (Enumeration)	A list of possible types of Army units by category (infantry, armor, medical, field artillery, air defense artillery, aviation, intelligence, engineer, military police, and logistics). User defined.
3.1 Echelon (Enumeration)	A separate level of command, such as a regiment, a division or a battalion.
3.2 Organizational Role	The common duty description within an organization type that captures the duties of the Soldier required to fill that position. User defined.
3.3 Organizational Role List (Enumeration)	A list of possible common job titles within an Army organization. User defined.
3.4 Commander	The person who is in command because of rank, position, or other circumstances. Field Manual (FM) 6-0.
3.5 Command Relationship (Association Class)	At theater level, the joint forces commander (JFC) commands Army forces operating outside the United States (see Joint Publication (JP) 2-0; JP 3-0; FM 3-100.7). A JFC is a combatant commander, sub-unified commander, or joint task force (JTF) commander authorized to exercise combatant command (COCOM) or operational control (OPCON) over a joint force. Combatant commanders provide strategic direction and operational focus by developing strategy, planning theater campaigns, organizing the theater, and establishing command relationships. JFCs plan, conduct, and support campaigns in the theater of war, subordinate theater campaigns, major operations, and battles. The four joint command relationships are COCOM, OPCON, tactical control (TACON), and support. FM 3-0, p. 2-11.
3.6 Command Relationship List (Enumeration)	A list of possible command relationships within the Army. Derived from FM 3-0.
3.6.1 Assigned	An assigned unit designation indicates a traditional command relationship with a parent unit. Derived from FM 3-0.
3.6.2 Attached	Higher headquarters task assigned this organization under a new parent organization. User defined, but derived from FM 3-0.

Input Data Element	Definition
3.6.3 OPCON	OPCON is inherent in COCOM. It is the authority to perform those functions of command that involve organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction necessary to accomplish the mission. FM 3-0, p. 2-12.
3.6.4 TACON	TACON is authority normally limited to the detailed and specified local direction of movement and maneuver of forces to accomplish a task. FM 3-0, p. 2-12.
3.6.5 Administrative Control (ADCON)	Unless the Secretary of Defense specifies otherwise, ADCON of Army forces remains within the Army chain of command, from lowest levels to the Secretary of the Army. FM 3-0, p.2-12.
3.7 Support Relationship (Association Class)	Joint doctrine establishes support as a command authority. Commanders establish it between subordinate commanders when one organization must aid, protect, or sustain another (see JP 0-2, JP 3-0). Under joint doctrine, there are four categories of support. The supporting command focuses on general and direct support. Mutual support and close support are based on proximity and combat actions. Army doctrine establishes four support relationships: direct, reinforcing, general, and general support reinforcing. FM 3-0, p.2-13.
3.8 Support Relationship List (Enumeration)	List of possible values for a support relationship within the Army. User defined.
3.8.1 General	Action given to the supported force as a whole rather than to a particular subdivision thereof. FM 3-0, p.2-13.
3.8.2 Mutual	The action that units render to one another against an enemy because of their assigned tasks, their position relative to one another and to the enemy, and their inherent capabilities. FM 3-0, p.2-13.
3.8.3 Close	The action of the supporting force against targets or objectives that are sufficiently near the supported force as to require detailed integration or coordination of the supporting action with fire, movement, or other actions of the supported force. FM 3-0, p.2-13.
3.8.4 Direct	A mission requiring a force to support another specific force and authorizing it to answer directly the supported force's request for assistance. FM 3-0, p.2-13.
3.9 TOE	The TOE prescribes the normal wartime mission, organizational structure, and personnel and equipment requirements for a military unit. It is the basis for an authorization document, the modified TOE. The TOE is not an authorization document. See http://www.fas.org/news/reference/lexicon/det.htm
3.10 Platform	Anything against which one can assign equipment, e.g., a vehicle, a tactical operations center, or a dismounted Soldier. User defined.
3.10.1 Mobility (Mounted/ Dismounted)	Choice value for the platform, either in a vehicle or not (mounted/dismounted). User defined.

Input Data Element	Definition
3.10.2 Aggregation	Choice value for the platform. Boolean, yes/no. Is the platform a singular entity, or does it represent a group of entities represented as one? User defined.
3.11 Operating Equipment	An abstract or aggregate class description of the final grouping of platform, communications capability, and antenna together. User defined.
3.12 Network	An assignment of bandwidth, waveform, and other communications capabilities to enable a group of Soldiers to communicate for a stated purpose. User defined.
3.13 Network Type (Enumeration)	A listing or enumeration of the network's purpose by name. The network type name of the network defines the purpose of the network (command, fires, logistics, and intelligence). User defined.
3.14 Voice Call Group	A list of recipients on a particular voice network. It is the result of a function that allows assignment of a voice network to all those who need to be on that network. User defined.
3.14.1 Scope (Global/Local)	A function of Soldier Radio Waveform (SRW) combat net radio (CNR) voice and how far the voice call is allowed to be forwarded.
3.15 Traffic Type List (Enumeration)	A listing of the type of traffic the network can carry.
3.15.1 Voice	Intended to denote an unrouted voice-only net, e.g., Single Channel Ground and Airborne Radio System (SINCGARS)
3.15.2 Data	Intended to denote a network able to route only data packets, e.g., SINCGARS data.
3.15.3 Voice and Data	Indicates a network that can send digital voice, e.g., voice over internet protocol, and data packets, e.g. Wideband Network Waveform (WNW).
3.16 COMBATXXI Radio	Subordinate elements define radio characteristics.
3.16.1 Name	Contains the name of the radio.
3.16.2 Model Number	Contains the model number of the radio.
3.16.3 Operating Frequency Range	The set of frequencies the radio is capable of transmitting.
3.16.4 Power	The output power of the radio, measured in milliwatts.
3.16.5 Firmware Version	The firmware revision this particular radio is running.
3.17 Data Rate	The number of bits that can be transmitted in a second.
3.17.1 Value	A number denoting bits transmitted. Bits transmitted must be used in conjunction with the appropriate data rate unit in order to define the magnitude of this value.
3.18 Data Rate Unit (Enumeration)	A description of the magnitude of the data rate value.

Input Data Element	Definition
3.19 Waveform Mode	The mode of the waveform, used by the transmitting device, for which this record contains data (e.g., WNW anti-jam).
3.19.1 Name	The name of the radio mode of transmitting.
3.20 Radio/Waveform Pairing	Identifies the compatible waveforms for each radio.
3.21 Performance Curve	Defines the performance characteristics of the radio operating a particular waveform in a specific mode.
3.21.1 Signal-to-Noise (SNR)	The SNR in decibels (dBs) for this particular completion rate.
3.21.2 Completion Rate	The completion rate at this received SNR
3.22 Mast	Defines the mast attached to the antenna.
3.22.1 Type	Defines whether the mast is folding, telescoping, or fixed.
3.23 Antenna	The device used to intensify the transmitted and received signal from a radio.
3.23.1 Radiating Height	The distance from the bottom of the antenna to where the antenna radiates the signal.
3.23.2 Name	The name of the antenna.
3.24 COMBATXXI Antenna	Sub-elements define characteristics of each antenna.
3.24.1 Gain	The gain, in dBs, of this antenna at this frequency.
3.24.2 Frequency	The frequency, in megahertz.
3.25 Antenna Gain	The maximum omnidirectional antenna dB gain.
3.26 COMBATXXI Antenna Gain	The maximum omnidirectional antenna dB gain.
3.27 Antenna Parameters	Sub-elements define characteristics of each antenna.
3.27.1 Record Date	The date stamp for the last update to this record.
3.27.2 Type	The name of the type of the antenna (e.g., yagi, dish, whip).
3.27.3 Polarization	The name of the polarization type the antenna uses (e.g., circular, horizontal, vertical).
3.28 COMBATXXI Antenna Parameters	Sub-element relates input source data to data used in COMBATXXI.
3.28.1 Source Identification (ID)	The ID of the record that defines the source for this antenna data.

Table B-1 concluded.

B-2. Data Outputs. The customary outputs required by other simulations from COMBATXXI for network analysis are the unit movement profiles over time. Specifically, over time, COMBATXXI reports unit names, heading, locations, and speed that the Joint Network Analysis Tool and OPNET can use. Figure B-4 summarizes these outputs, which are organized into two loggers: movement logger and spawned logger. The movement logger contains information related to movement of the entities within the scenario. A record is produced whenever an entity encounters an event that changes its speed. These events include encountering a terrain boundary, an order to change speed, a change type of road, encountering an obstacle (natural or emplaced), or reaching a control measure. Table B-2 provides the data output dictionary for the movement logger. The spawned logger is a main logger file that contains unique initialization information for all entities/systems a COMBATXXI scenario employs. Other loggers will reference this information by way of the logger's appropriate ID. (Note: The ID list for each entity may be different for each replication of the scenario.) Table B-3 provides the data output dictionary for the spawned logger.

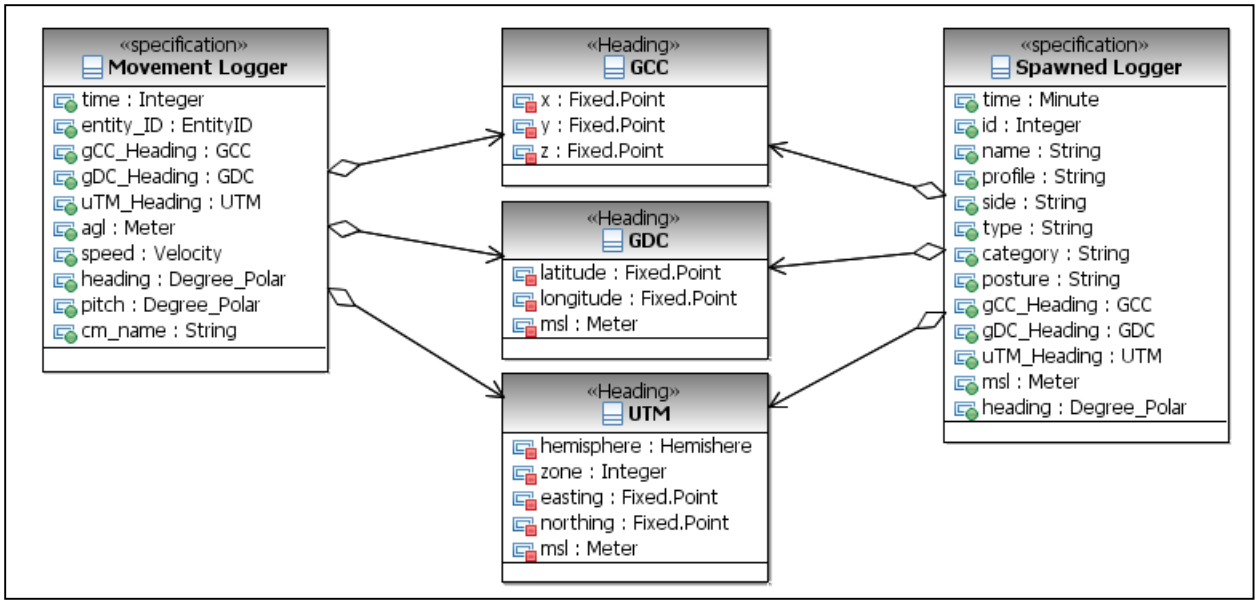

Figure B-4. COMBATXXI Output.

Table B-2. COMBATXXI Movement Logger Data Output Dictionary.

Field #	Geocentric Coordinates (GCC) Heading	Geodetic Coordinates (GDC) Heading	Universal Transverse Mercator (UTM) Heading	Description	Example/Notes
1	time	time	time	Event time (minutes)	100.00
2	entity_id	entity_id	entity_id	Unique identifier for entity that is moving which matches the entity "ID" in the spawned logger	1038
3	x	latitude	hemisphere	GCC: Entity's initial x value GDC: Entity's initial latitude position UTM: Entity's initial hemisphere	GCC: -1468716.96304 GDC: 27.122 UTM: north
4	y	longitude	zone	GCC: Entity's initial y value GDC: Entity's initial longitude position UTM: Entity's initial zone	GCC: -5083860.67515 GDC: 57.087 UTM: 13
5	z	msl	easting	GCC: Entity's initial z value GDC: Entity's height above mean sea level (MSL) (meters) UTM: Entity's initial easting.	GCC: 3548839.34633 GDC: 58.23 UTM: 397162.158872
6	na1	na1	northing	GCC: Not applicable (not used) GDC: Not applicable (not used) UTM: Entity's initial northing	GCC: GDC: UTM: 3765533.39817
7	na2	na2	msl	GCC: Not applicable (not used) GDC: Not applicable (not used)	GCC: GDC: UTM: 58.23

Field #	Geocentric Coordinates (GCC) Heading	Geodetic Coordinates (GDC) Heading	Universal Transverse Mercator (UTM) Heading	Description	Example/Notes
				UTM: Entity's height above mean sea level (MSL) (meters)	
8	agl	agl	agl	Entity's height above ground level (AGL) (meters)	25.68
9	speed	speed	speed	Entity's speed (meters/second)	0.361
10	heading	heading	heading	Entity's heading	145.7
11	pitch	pitch	pitch	Entity's pitch	-4.709
12	cm_name	cm_name	cm_name	Name of control measure at which the entity is currently located. For "point" control measures, the control measure name will appear the first time the entity has closed to within a distance that is less than or equal to the tolerance associated with the control measure.	User defined or " "null"

Table B-2 concluded.

Table B-3. COMBATXXI Spawned Logger Data Output Dictionary.

Field #	GCC Heading	GDC Heading	UTM Heading	Description	Example/Notes
1	time	time	time	Initiation time (minutes)	0.0000
2	id	id	id	Unique entity ID number	1038
3	name	name	name	Entity's name	INF_XM29_600
4	profile	profile	profile	Entity's profile	INF_XM29
5	side	side	side	String description of entity's side	RED, BLUE
6	type	type	type	Entity type	TEAM/B_1MAN
7	category	category	category	Entity category	HUMAN
8	posture	posture	posture	Entity posture	ANY, STANDING, etc.
9	x	latitude	hemisphere	GCC: Entity's x position GDC: Entity's latitude position UTM: Entity's hemisphere	GCC: -1479531.857955 GDC: 34.009582 UTM: north
10	y	longitude	zone	GCC: Entity's y position GDC: Entity's longitude position UTM: Entity's zone position	GCC: -5081747.170742 GDC: -106.232723 UTM: 13
11	z	na1	easting	GCC: Entity's z position GDC: Not applicable (not used) UTM: Entity's easting position	GCC: 3547383.596685 GDC: UTM: 386027.699139
12	na1	na2	northing	GCC: Not applicable (not used) GDC: Not applicable (not used) UTM: Entity's northing position	GCC: GDC: UTM: 3764274.928458
13	na2	msl	msl	GCC: Not applicable (not used) GDC: Entity's height above MSL (meters) UTM: Entity's height above MSL (meters)	GCC: GDC: 100.000157 UTM: 100.000157
14	agl	agl	agl	Entity's initial height AGL (meters)	0.000
15	heading	heading	heading	Entity's initial heading	0.000

Appendix C. Joint Network Analysis Tool (JNAT)

C-1. Data Inputs. The JNAT requires authoritative input sources to conduct connectivity and flow analysis. The analysis focuses on outputs measured without the need for a high-resolution network model. The focus of the data inputs in this document is limited to network-related data (figure C-1).

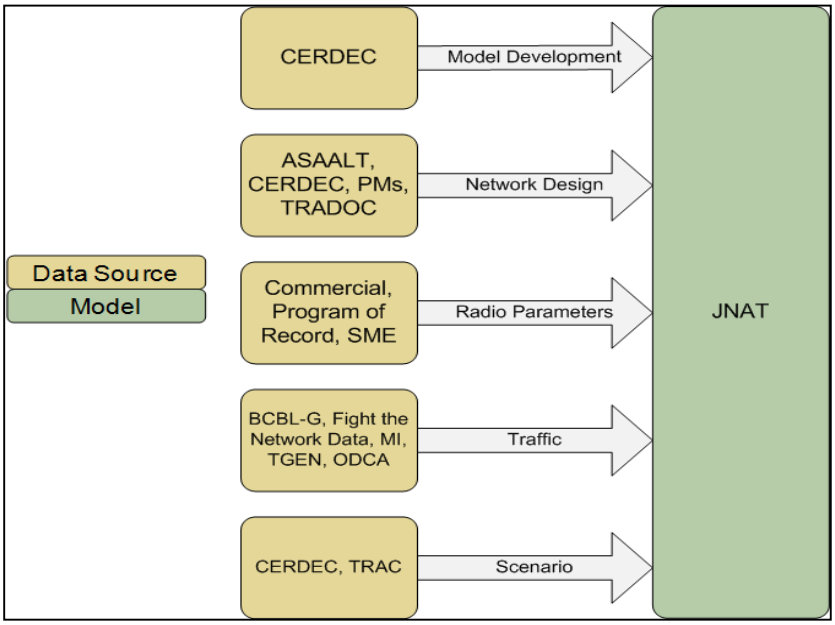

Figure C-1. General JNAT Data Inputs.

The Communications-Electronics Research Development and Engineering Center (CERDEC) maintains the JNAT model, providing model development oversight, including code development and conduct of simulations. The community of practice (CoP) develops the network design inputs. Figure C-2 diagrams the required network inputs for JNAT. Table C-1 provides the specific JNAT data input dictionary.

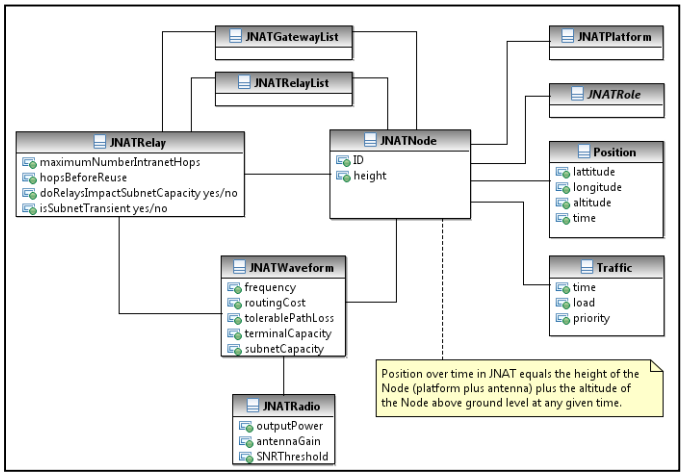

Figure C-2. JNAT Network Data Inputs.

Table C-1. JNAT Data Input Dictionary.

Input Data Element	Definition
1.0 JNAT Data Entities	Contains the name of the modeled entity.
2.0 JNAT Platform	Platform used in mounting a network device.
3.0 JNAT Role (Abstract)	Web-accessible analysis environment designed to examine network performance and facilitate key architectural decisions.
4.0 JNAT Relay	Text files specifying waveform behavior of each subnet. Each row represents an individual subnet. Note that any subnet not listed in this file will be treated as an ad hoc network by default (i.e., all nodes can relay, all nodes can gateway, no limit on intranet hops, three hops before frequencies can be reused, and relays do detract from capacity).
4.1 Maximum Number Intranet Hops	Network paths that require more than this number of intranet hops are not allowed. This is used for systems that allow only a limited number of relays, such as the Enhanced Position Location and Reporting System (EPLRS).
4.2 Hops Between Reuse	Number of hops required before another transmitter can reuse the same frequency/time slot.
4.3. Relays Impact Subnet Capacity	Boolean, yes/no. If yes, any traffic relayed will detract from capacity.
4.4 Subnet Transient	Boolean, yes/no. Function is unavailable.
5.0 JNAT Relay List	List of integers. This identifies which nodes are members of the subnet associated with this row. This can be a list of integer Cisco Network Admission Control (CNAC) node identifications (IDs) separated by commas and no white space. Alternatively, the list can also contain a range of values indicated by a dash. This is useful for systems like the Single Channel Ground and Airborne Radio System (SINCGARS) or Link 16, in which only pre-specified nodes may relay.
6.0 JNAT Node	Sub-elements define node properties.
6.1 ID	List of integers. This identifies which nodes are members of the subnet associated with this row. This can be a list of integer CNAC node IDs separated by commas and no whitespace. Alternatively, the list can also contain a range of values indicated by a dash.
6.2 Height	Antenna height in meters or unmanned aerial vehicle height above the ground.
7.0 JNAT Gateway List	This list identifies which nodes are members of the subnet associated with this row. This can be a list of integer CNAC node IDs separated by commas and no whitespace. Alternatively, the list can also contain a range of values indicated by a dash. This is useful for systems like Blue Force Tracker (BFT), where there is only one node allowed to gateway to/from external subnets.
8.0 JNAT Waveform	Sub-elements define waveform properties.

Input Data Element	Definition
8.1 Frequency	Contains the name of the channel frequency available to use, identified from radio specifications.
8.2 Routing Cost	Low numbers represent the most-preferred path; high numbers represent the least-preferred path.
8.3 Tolerable Path Loss	Identify from radio specifications.
8.4 Terminal Capacity	This is the maximum capacity that a terminal can transmit, assuming all other subnet members are idle. Note: If the relay file is empty regarding this subnet and configured such that relays detract from capacity, then this should be the terminal capacity before relaying. Otherwise, it should be the terminal capacity after relaying.
8.5 Subnet Capacity	This is the maximum capacity that all terminals in the same neighborhood must share. Note: If the relay file is empty regarding this subnet or is configured such that relays detract from capacity, then this should be the neighborhood capacity before relaying. Otherwise, it should be the neighborhood capacity after relaying.
9.0 JNAT Radio	Sub-elements define radio properties.
9.1 Output Power	Identify from radio specifications.
9.2 Antenna Gain	Identify from radio specifications.
9.3 Signal-to-Noise Ratio (SNR) Threshold	Identify from radio specifications.
10.0 Traffic	Sub-elements define traffic properties.
10.1 Time	Typically, this value is the time in seconds from the beginning of the simulation.
10.2 Load	This field contains the name of the text file containing the load profile. Each row represents an individual information exchange requirement (IER) or flow. The time stamps must be monotonically increasing with a constant delta between them, and they must match those in the positions file.
10.3 Priority	Low numbers represent the most preferred; high numbers represent the least preferred.
11.0 Position	Sub-elements define location of antenna
11.1 Latitude	Contains a part of the location units in universal transverse mercator (UTM) easting (meters) or latitude (degrees).
11.2 Longitude	Contains a part of the location units in UTM northing (meters) or longitude (degrees).
11.3 Altitude	Contains the antenna height in meters.
11.4 Time	Represents the time in seconds from the beginning of the simulation.

Table C-1 concluded.

C-2. Data Outputs. JNAT outputs, specifically traffic start and end times, may be used as delay inputs to the Advanced Warfighting Simulation (AWARS) and Combined Arms Analysis Tool for the 21st Century (COMBATXXI). Figure C-3 depicts JNAT outputs. Tables C-2 through C-9 provide the JNAT output data definitions for single subnet and multiple subnet output files.

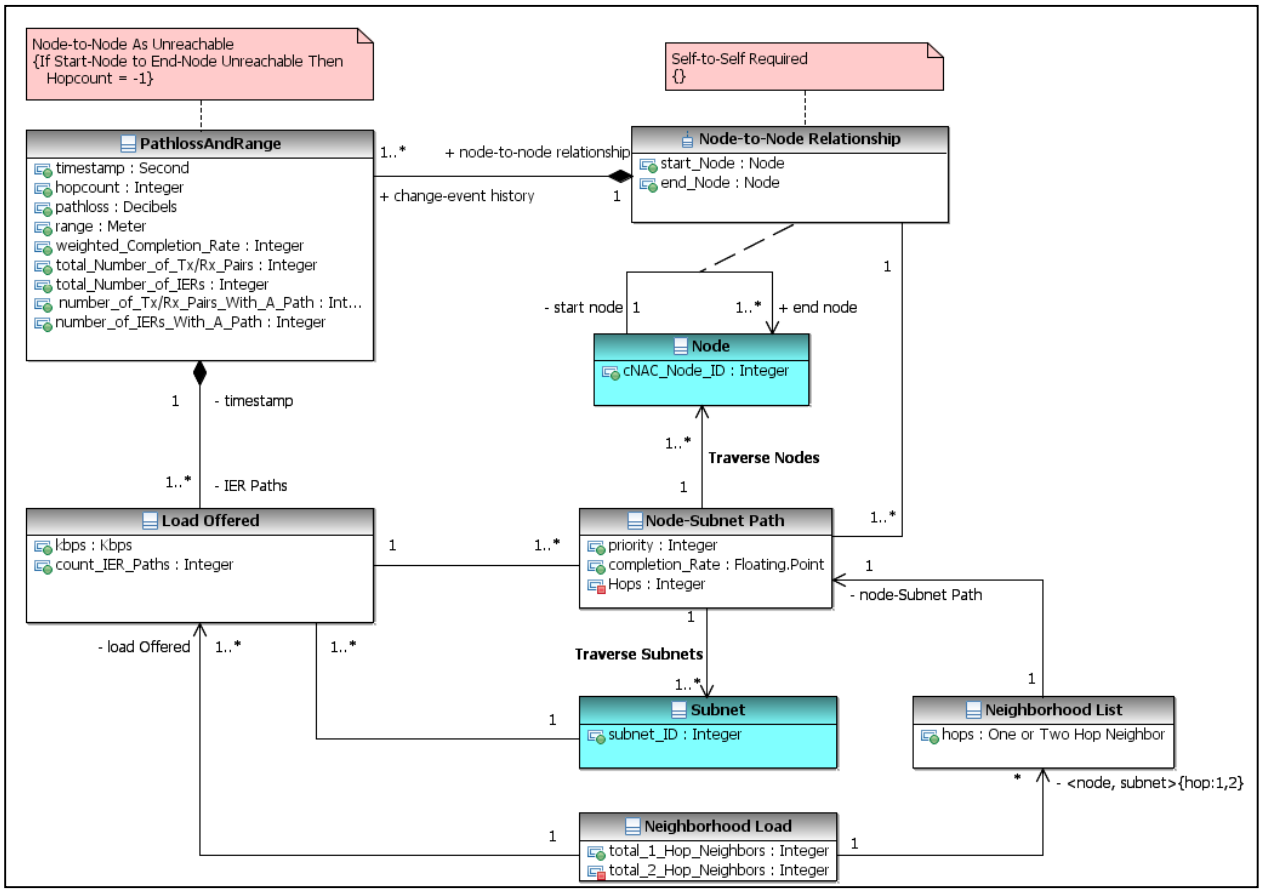

Figure C-3. JNAT Output.

C-2.1. Single Subnet Output Files.

C-2.1.1. Pathloss and Range File. Listed as *tmp_<runid>_pathloss_connfile.txt*, this file contains the pathloss and range between all source/destination pairs in the network.

Table C-2. JNAT Pathloss and Range File Data Output Dictionary (Single Subnet).

Time Stamp	Node A	Node B	Pathloss	Range
Value of the current time. There should be one row for every pair of nodes at the first time step. Thereafter, listing a row is necessary only when changes take place. That is, if it is a static scenario with no mobility, then all possible pathloss values will be provided at t=0 and no other time steps.	Integer ID of the first node	Integer ID of the second node	Pathloss in decibels	Range in meters

C-2.1.2. Hopcount File. Listed as *tmp_<runid>_matrix_hops_<timestamp>.txt*, this file contains the hopcount for every pair of nodes in the network. Node pairs that are unreachable are indicated by a "-1." Output file in matrix format (first row is node ID, first column is node ID, and each grid entry is the corresponding number of hops).

Table C-3. JNAT Hopcount File Data Output Dictionary (Single Subnet).

-1	CNAC Node ID 1	CNAC Node ID 2	…
CNAC Node ID 1	Hopcount (node 1 to node 1)	Hopcount (node 2 to node1)	…
CNAC Node ID 2	Hopcount (node 1 to node 2)	Hopcount (node 2 to node2)	…

C-2.1.3. Pathloss File. Listed as *tmp_<runid>_matrix_ploss_<timestamp>.txt*, this file contains the pathloss for every pair of nodes in the network. This output file is in matrix format (first row is node ID, first column is node ID, and each grid entry is the corresponding pathloss).

Table C-4. JNAT Pathloss File Data Output Dictionary (Single Subnet).

-1	CNAC Node ID 1	CNAC Node ID 2	…
CNAC Node ID 1	Hopcount (node 1 to node 1)	Hopcount (node 2 to node1)	…
CNAC Node ID 2	Hopcount (node 1 to node 2)	Hopcount (node 2 to node2)	…

C-2.2. Multiple Subnet Output Files.

C-2.2.1. Load Statistics File. Listed as *tmp_<runid>_load_statistics.txt*, this output file contains overall network connectivity, load, and completion rate statistics. Each time stamp will have one line.

Table C-5. JNAT Load Statistics File Data Output Dictionary.

Time Stamp	Total # Tx/Rx Pairs	# Tx/Rx Pairs with a Path	Total # IERs	# IERs with a Path	Weighted Completion Rate	Load Offered to Subnet 0 (kilobits per second (kbps))	Load Offered to Subnet 1 (kbps)
Float. Typically, time in seconds from the beginning of the simulation.	Integer	Integer	Integer	Integer. Note that a multicast IER with at least one reachable member is considered an IER with a path.	Integer	Integer. Offered load counts each IER only once for each subnet it traverses (i.e., does not count relays or reentry into another fragment of the same subnet). Offered load counts only IERs that have a path.	Integer

C-2.2.2. IER Subnet Paths File. Listed as *tmp_<runid>_ier_subnet_paths_<timestamp>.txt*, this is an output file containing completion rate and network path for each IER/Flow.

Table C-6. JNAT IER Subnet Path Data Output Dictionary.

Source ID	Destination ID	Offered Load (kilobits per second)	Priority	Completion Rate	Semicolon Delimiter	List of Subnets Traversed	Semicolon Delimiter	List of Nodes Traversed
Integer. CNAC node ID of the source	Integer. For unicast destinations, this is the CNAC node ID of the destination. For multicast destinations, this is the CNAC group ID.	Float. Same value as indicated in traffic input file. Does not include effect of relays.	Integer. Same value as indicated in traffic input file.	Float. Completion rate of this particular IER.	Indicates beginning of list of subnets traversed.	Integer. Each subnet traversed (entry for each hop on that subnet).	Indicates beginning of list of nodes traversed.	Integers. Each node traversed (entry for each hop on that subnet).

C-2.2.3. Hopcount File. Listed as *tmp_<runid>_matrix_hops_<timestamp>.txt*, this file contains the hopcount for every pair of nodes in the network. Node pairs that are unreachable show "-1." Output file in matrix format (first row is node ID, first column is node ID, and each grid entry is the corresponding number of hops).

Table C-7. JNAT Hopcount File Data Output Dictionary (Multiple Subnets).

-1	CNAC Node ID 1	CNAC Node ID 2	…
CNAC node ID 1	Hopcount (node 1 to node 1)	Hopcount (node 2 to node1)	…
CNAC node ID 2	Hopcount (node 1 to node 2)	Hopcount (node 2 to node2)	…

C-2.2.4. Neighborhood Load File. Listed as *tmp_<runid>_neighborhood_load_by_priority_<timestamp>.txt*, this output file contains neighbor and load statistics for every <node, subnet> in the network.

Table C-8. JNAT Neighborhood Load File Data Output Dictionary.

CNAC Node ID	CNAC Subnet ID	Number of 1 Hop Neighbors	Number of 2 Hop Neighbors	Node RF Load (kilobits per second)	Node Neighborhood Load (kilobits per second)	Subnet RF Load (kilobits per second)	Subnet Offered Load (kilobits per second)	Semicolon Delimiter	Node RF Load Per Priority	Semicolon Delimiter	Node Neighborhood Load Per Priority
Integer	Integer	Integer. Number of 1 hop neighbors associated with CNAC node ID indicated in first column on CNAC. Subnet ID indicated in second column.	Integer. Number of 2 hop neighbors associated with CNAC node ID indicated in first column on CNAC. Subnet ID indicated in second column.	Float. Load transmitted by this node. For subnets that are configured such that relays detract from capacity (e.g., typical mobile ad-hoc network (MANET). This includes the load the node is sourcing as well as the load that the node is relaying on behalf of others.	Float. Sum of all load transmitted by nodes within N hops of the node listed in the first column (N is the number of hops before frequency reuse is allowed, as defined in the relay file; default for N is 3). For subnets that are configured such that relays detract from capacity (e.g., typical MANET), this includes the load those nodes are sourcing as well as the load that those nodes are relaying on behalf of others.	Float. Total RF load on the subnet. This includes the load across all fragments if the subnet is fragmented. For subnets that are configured such that relays detract from capacity (e.g., typical MANET), this includes load that is sourced as well as load that is relayed on behalf of others.	Float. Total load offered to this subnet. This includes the load across all fragments if the subnet is fragmented.	Indicates beginning of the list of subnets traversed.	Float. This "node RF load" described earlier is listed per priority.	Indicates beginning of the list of nodes traversed.	Float. This "node neighborhood load" described earlier is listed per priority.

C-2.2.5. Neighborhood List File. Listed as *tmp_<runid>_neighborhood_info_<timestamp>.txt*, this is an output file containing a list of one- and two-hop neighbors for every <subnet, node> in the network. Pairs that are greater than two hops apart are not listed.

Table C-9. JNAT Neighborhood List File Data Output Dictionary.

CNAC Subnet ID	Node A	Node B	One- or Two-Hop Neighbor
Integer	Integer. CNAC node ID.	Integer. CNAC node ID.	Integer. "1" or "2" to indicate how many hops apart the two nodes listed in columns two and three are from each other.

Appendix D. OPNET

D-1. Data Inputs. OPNET is a commercially developed, high-resolution network analysis simulation tool. This simulation requires significant amounts of highly technical information regarding radios in order to model networks at the pack-transport-level of simulation. Figure D-1 outlines the general inputs from a variety of organizations needed for an OPNET simulation run.

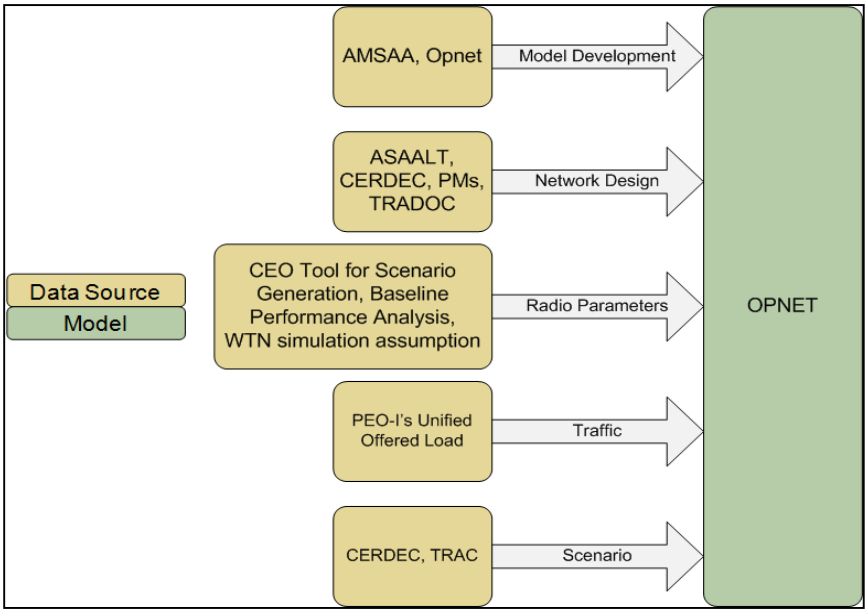

Figure D-1. General OPNET Data Inputs.

The Army Materiel Systems Analysis Activity (AMSAA) maintains oversight of the Army representation of radios in OPNET. The OPNET developer is based in Bethesda, MD. It owns and develops the network simulation software, including maintaining nondisclosure of proprietary representations of real network components. The community of practice (CoP) develops the network design inputs. The Program Executive Office - Information (PEO-I) generates traffic for the model scenarios through the unified offered load (UOL) tool. The Communications-Electronics Research Development and Engineering Center (CERDEC) and the Training and Doctrine Command (TRADOC) Analysis Center (TRAC) provide scenario setting for network design and development. Figures D-2 and D-3 detail specific inputs that a simulation in OPNET software requires.

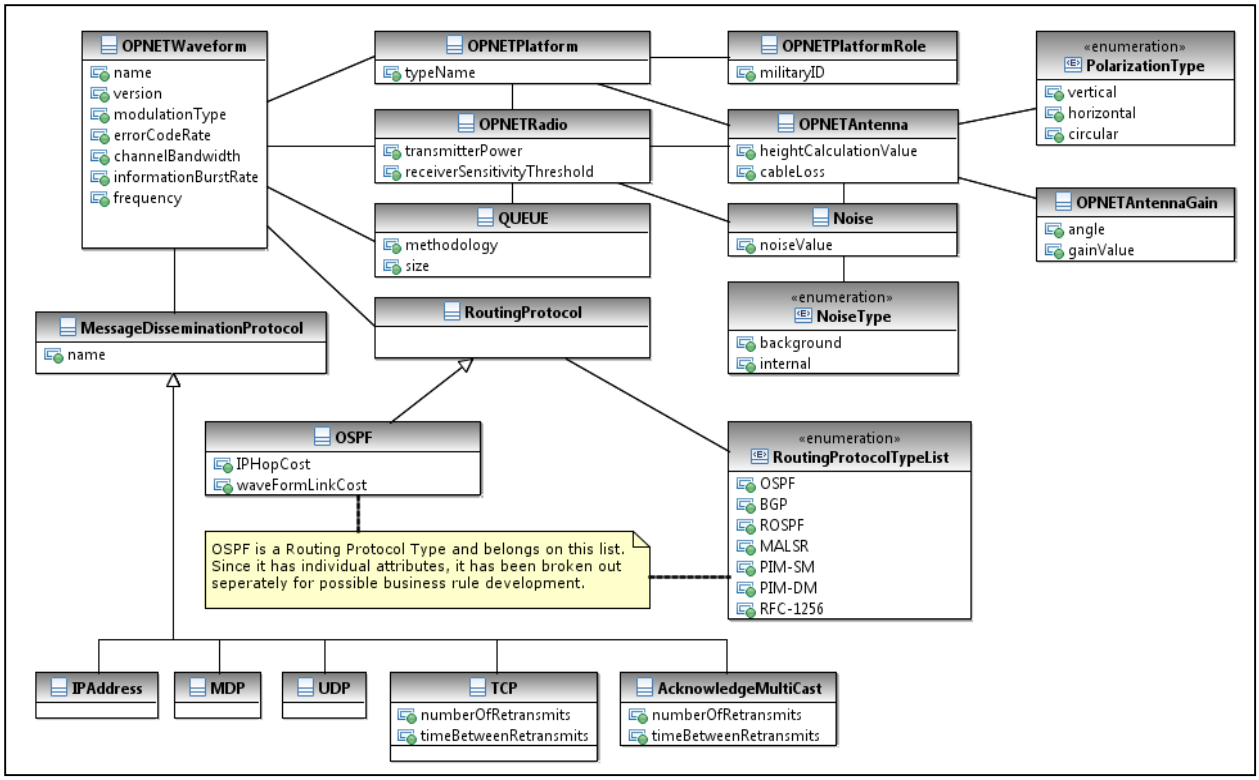

Figure D-2. OPNET Performance Data Inputs.

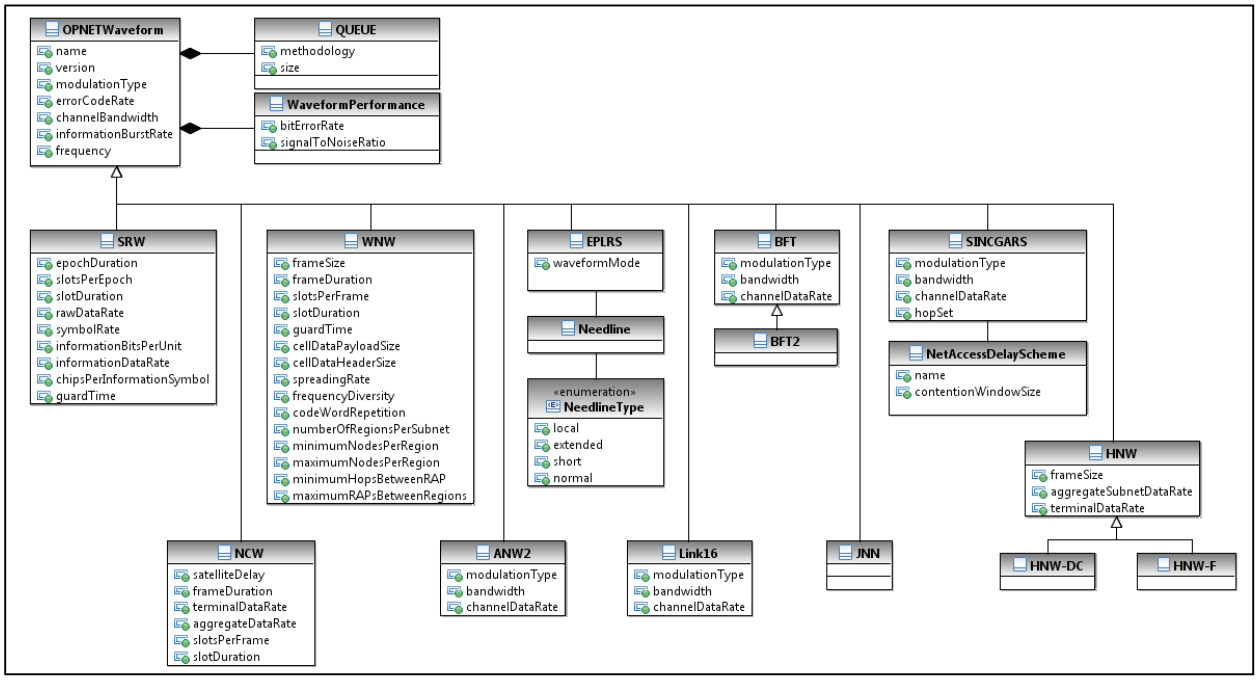

Figure D-3. OPNET Network Data Inputs.

Table D-1 defines OPNET data inputs.

Table D-1. OPNET Data Input Dictionary.

Input Data Element	Definition
1.0 OPNET Platform	Within OPNET, an entity that can have communications systems assigned to it. This would include a vehicle, a tactical operations center shelter or a Soldier role. User defined.
1.1 Type Name	The platform type (vehicle, Soldier, shelter) represented within OPNET. User defined.
2.0 OPNET Platform Role	The function that the unit has in the organization. User defined.
2.2 Military Identification (ID)	The unique identifier of each unit. User defined.
3.0 OPNET Antenna	The radiating element of the radio. User defined.
3.1 Height Calculation Value	The mounting height on the vehicle plus the height of the mast plus the distance of the antenna feed point to the end of the antenna. User defined.
3.2 Cable Loss	The amount of attenuation the signal undergoes between the antenna and the radio. User defined.
4.0 Polarization Type (Enumeration)	The text description of the orientation of the radio frequency (RF) wave with respect to the surface of the earth. User defined.
4.1 Vertical	The orientation of the RF wave perpendicular to the plane of the earth's surface. User defined.
4.2 Horizontal	The orientation of the RF wave parallel to the plane of the earth's surface. User defined.
4.3 Circular	The RF wave movement that crosses through all planes. User defined.
5.0 OPNET Antenna Gain	The increase in magnitude of the signal/amplification when it passes through the antenna. User defined.
5.1 Angle	The azimuth degrees relative to zero. User defined.
5.2 Gain Value	The increase in magnitude of the signal/amplification when it passes through the antenna, expressed in decibels (dBs). User defined.
6.0 Noise	The amount of energy in a channel of interest not desired for the intended transmission. User defined.
6.1 Value	dBs. User defined.
7.0 Noise Type (Enumeration)	The description of the noise source. User defined.
7.1 Background	Noise that is sourced external to the radio antenna. User defined.
7.2 Internal	Noise that is internal to the radio antenna. User defined.
8.0 OPNET Waveform	The type of communication of interest, for example, Wideband Network Waveform (WNW), Enhanced Position Location Reporting System (EPLRS). User defined.
8.1 Name	Name of the waveform used. User defined.
8.2 Version	Name of the version release of the waveform used. User defined.

Input Data Element	Definition
8.3 Modulation Type	Additional information (or signal) provided to an electronic or an optical signal carrier. User defined.
8.4 Error Code Rate	The fraction of total bits in the information stream that are error control bits. User defined.
8.5 Channel Bandwidth	The amount of hertz between the 3-dB drop-off points of the channel. User defined.
8.6 Information Burst Rate	The number of bits per second of information that the transmitter can pass when it is transmitting. User defined.
8.7 Frequency	The carrier frequency band for signal, measured in cycles per second. User defined.
9.0 OPNET Radio	The transmitting device of interest. User defined.
9.1 Transmitter Power	The amount of wattage put out by the transmitter, before antenna gain. User defined.
9.2 Receiver Sensitivity Threshold	The minimum power received, such that the receiver is capable of intelligently operating on. User defined.
10.0 Queue	The storage capacity of the radio for messages waiting to be transmitted. User defined.
10.1 Methodology	The transmission scheme used to order messages in queue. User defined.
10.2 Size	The maximum capacity of the transmission in queue. User defined.
11.0 Routing Protocol	The algorithm used to determine which routes transmissions use between a source and a destination. User defined.
12.0 Routing Protocol List (Enumeration)	Sub-elements define routing protocols.
12.1 Open Shortest Path First (OSPF)	Protocol commonly used to find the shortest path between two nodes. User defined.
12.2 Border Gateway Protocol (BGP)	Used to determine gateway between boundaries. User defined.
12.3 Radio Open Shortest Path First (ROSPF)	Protocol used within the domain of the waveform. User defined.
12.4 Mobile Abstracted Link State Routing (MALSR)	Indicates that WNW uses MALSR protocol. User defined.
12.5 Protocol Independent Multicast – Sparse Mode (PIM-SM)	Indicates that WNW uses PIM-SM protocol when there are low node neighbor densities. User defined.
12.6 PIM-Dense Mode (PIM-DM)	Indicates that WNW uses PIM-DM protocol when there are high node neighbor densities. User defined.

Input Data Element	Definition
12.7 Request for Comments – 1256 (RFC-1256)	Router discovery protocol.
13.0 OSPF	Sub-elements define OSPF parameters
13.1 Internet Protocol (IP) Hop Cost	The value incurred for each use of a hop on the IP layer. User defined.
13.2 Waveform Link Cost	The value incurred for each use of a hop on the waveform. User defined.
14.0 Message Dissemination Protocol (MDP)	Sub-element defines MDP.
14.1 Name	Name of the protocol used.
15.0 Transmission Control Protocol (TCP)	Protocol used to regulate message transfer. User defined.
16.0 Acknowledge Multicast	Reliable protocol in messages in which the destination acknowledges receipt of transmission. User defined.
17.0 IP	Protocol used for message transfer. User defined.
18.0 User Datagram Protocol (UDP)	Protocol used to transfer messages across the Internet as part of the internet protocol suite. User defined.
19.0 Waveform Performance	Sub-elements define waveform performance.
19.1 Bit Error Rate	The fraction of bits sent from source to destinations that are received in error. User defined.
19.2 Signal-to-Noise Ratio (SNR)	The strength of the intended received signal relative to the noise at the receiver. User defined.
20.0 Soldier Radio Waveform (SRW)	Sub-elements define SRW properties.
20.1 Epoch Duration	The length of time needed for a cycle of repeating time slots. User defined.
20.2 Slots Per Epoch	The number of time slots within an epoch. User defined.
20.3 Slot Duration	The amount of time needed for one time slot. User defined.
20.4 Raw Data Rate	The bits per second that the transmitter can send while it is transmitting, including information and error control bits. User defined.
20.5 Symbol Rate	The number of symbols per second. User defined.
20.6 Information Data Rate	The number of bits per second that the transmitter can transmit while on, not including overhead or error control bits. User defined.

Input Data Element	Definition
20.7 Chips Per Information Symbol	The number of changes to the baseband signal in each duration of a symbol. User defined.
20.8 Guard Time	The duration between the end of the transmission part of a timeslot and that start of the next timeslot. User defined.
21.0 WNW	Sub-elements define WNW properties.
21.1 Frame Size	The quantity of time slots in a frame. User defined.
21.2 Frame Duration	The time length of a frame. User defined.
21.3 Slots Per Frame	The quantity of time slots in a frame. User defined.
21.4 Slot Duration	The time length of a slot. User defined.
21.5 Guard Time	The duration between the end of the transmission part of a time slot and that start of the next time slot. User defined.
21.6 Cell Data Payload Size	The number of bits a cell carries. User defined.
21.7 Cell Data Header Size	The number of bits in the header of each cell. User defined.
22.0 Spreading Rate	The number of changes to the baseband signal in each duration of a symbol. User defined.
22.1 Frequency Diversity	The number of frequencies that each symbol is duplicated on during the transmission. User defined.
22.2 Code Word Repetition	The number of times each symbol is duplicated during the transmission. User defined.
22.3 Number of Regions Per Subnet	The number of distinct and different channel groupings that the subnet can contain. User defined.
22.4 Minimum Nodes Per Region	The minimum number of WNW nodes that a region can have. User defined.
22.5 Maximum Nodes Per Region	The maximum number of WNW nodes that a region can accommodate. User defined.
22.6 Minimum Hops Between Route Access Protocol (RAP)	The minimum number of hops that must exist for two RAPs between the same two regions to be elected. User defined.
22.7 Maximum RAP Between Regions	The maximum number of RAPs that can exist between any two regions. User defined.
23.0 EPLRS	Sub-elements define EPLRS properties.
23.1 Waveform Mode	One of the seventeen very high-speed integrated circuit modes that determine the data payload capacity and signal-to-noise ratio performance of the EPLRS signal. User defined.
24.0 Needline	A set of common slots for communication between any two or more EPLRS nodes. User defined.

Input Data Element	Definition
25.0 Needline Type (Enumeration)	Sub-elements define types of needlines.
25.1 Local	A needline that allows only one relay between source and destination. User defined.
25.2. Extended	A needline that allows three relays between source and destination. User defined.
25.3 Short	A needline in which a transmitting node can monopolize the net only for that one particular transmission. User defined.
25.4 Normal	A needline in which a transmitting node can monopolize the net for as long as it takes to transmit the entire message. User defined.
26.0 Net-centric Waveform (NCW)	Sub-elements define NCW properties.
26.1 Satellite Delay	The amount of time it takes for the message to traverse the uplink and downlink to and from the satellite. User defined.
26.2 Frame Duration	The time length of a frame. User defined.
26.3 Terminal Data Rate	The maximum number of bits per second (including information bits and overhead bits) that each terminal can transmit. User defined.
26.4 Aggregate Data Rate	The maximum number of bits per second (including information bits and overhead bits) that all terminals combined can transmit. User defined.
26.5 Slots Per Frame	The number of time slots in a frame. User defined.
26.6 Slot Duration	The time duration of a time slot. User defined.
27.0 Highband Networking Waveform (HNW)	Sub-elements define HNW properties.
27.1 Frame Size	The quantity of time slots in a frame. User defined.
27.2 Aggregate Subnet Data Rate	The maximum number of bits per second (including information bits and overhead bits) that all terminals combined can transmit. User defined.
28.0 Terminal Data Rate	The maximum number of bits per second (including information bits and overhead bits) that each terminal can transmit. User defined.
29.0 HNW-DC	A specific implementation of HNW. User defined.
30.0 HNW-F	A specific implementation of HNW. User defined.
31.0 Blue Force Tracker (BFT)	Sub-elements define BFT properties.
31.1 Modulation Type	The addition of information (or the signal) to an electronic or optical signal carrier. User defined.

Input Data Element	Definition
31.2 Bandwidth	The spectral space occupied by the channel between its 3-dB drop-off points. User defined.
31.3 Channel Data Rate	The bits per second that the transmitter is capable of transmitting, including the information bits, error control bits, and all overhead bits. User defined.
32.0 BFT2	Version 2 of BFT.
33.0 ANW2	Sub-elements define ANW2 properties.
33.1 Modulation Type	The addition of information (or the signal) to an electronic or optical signal carrier. User defined.
33.2 Bandwidth	The spectral space occupied by the channel between its 3-dB drop-off points. User defined.
33.3 Channel Data Rate	The bits per second that the transmitter is capable of transmitting, including the information bits, error control bits, and all overhead bits. User defined.
34.0 Single Channel Ground and Airborne Radio System (SINCGARS)	Sub-elements define SINCGARS properties.
34.1 Modulation Type	The addition of information (or the signal) to an electronic or optical signal carrier. User defined.
34.2 Bandwidth	The spectral space occupied by the channel between its 3-dB drop-off points. User defined.
34.3 Channel Data Rate	The bits per second that the transmitter is capable of transmitting, including the information bits, error control bits, and all overhead bits. User defined.
34.4 Hop Set	The set of channels that radios in the net can use in any order to transmit and receive. User defined.
35.0 Net Access Delay Scheme	The strategy that determines how long a node waits to transmit after a busy net is detected. User defined.
35.1 Name	The type of net access delay scheme employed. User defined.
35.2 Contention Window Size	The amount of time that a node waits until attempting the transmission again. User defined.
36.0 Link 16	Sub-elements define Link 16 properties.
36.1 Modulation Type	The addition of information (or the signal) to an electronic or optical signal carrier. User defined.
36.2 Bandwidth	The spectral space occupied by the channel between its 3-dB drop-off points. User defined.
36.3 Channel Data Rate	The bits per second that the transmitter is capable of transmitting, including the information bits, error control bits, and all overhead bits. User defined.
37.0 Joint Network Node (JNN)	JNN is a gateway node into and out of the Warfighter Information Network-Tactical (WIN-T). User defined.

Table D-1 concluded.

D-2. Data Outputs. Other simulations use OPNET data that are customarily based on analysis from the following outputs. The outputs available cover most of the detailed data of interest for network analysis. Figure D-4 depicts the data outputs, and table D-2 defines the output data elements.

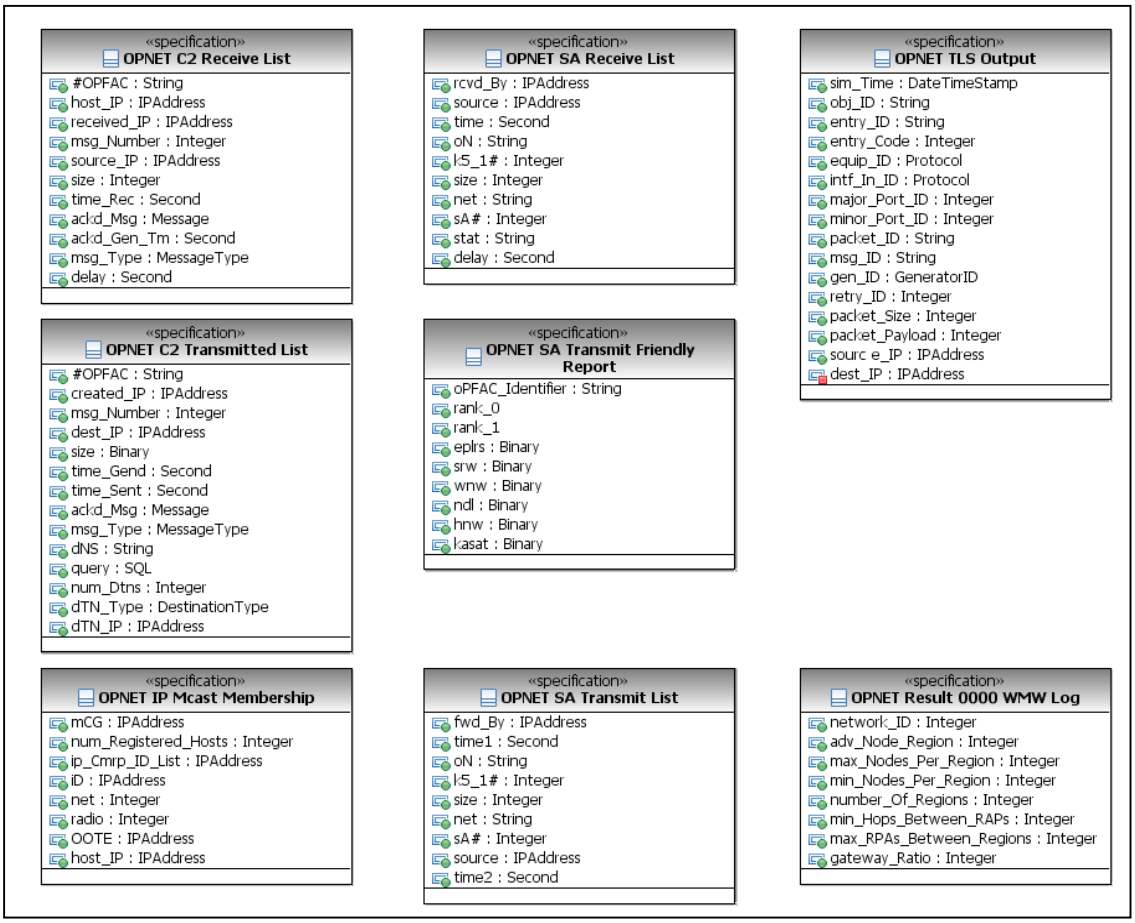

Figure D-4. OPNET Output.

Table D-2. OPNET Data Output Dictionary (by File Name).

Column	Data Element	Definition
C2_rx_list.txt		
1	#OPFAC	Operational Facility unit designation text.
2	HOST_IP	Internet protocol (IP) address of the current host device.
3	RECEIVED_IP	IP address of the receiving device.
4	MSG_NUMBER	Message type count.
5	SOURCE_IP	IP address of the sending device.
6	SIZE	Size in bits of the pack being transmitted.
7	TIME_REC	Time in seconds from the beginning of the simulation.
8	ACKD_MSG	Flag for message acknowledgment requirement.
9	ACKD_GEN_TM	Time stamp, in seconds, from the beginning of the simulation, when the acknowledgement message was sent.
10	MSG_TYPE	Type of message being received.
11	DELAY	Total transmission delay in seconds.
C2_tx_list.txt		
1	#OPFAC	Unit designation text.
2	CREATED_IP	IP address dynamically assigned to sending device.
3	MSG_NUMBER	Message type count.
4	DEST_IP	IP address of the destination device.
5	SIZE	Size in bits of the pack being transmitted.
6	TIME_GEND	Time in seconds from the beginning of the simulation, indicating when the message was generated.
7	TIME_SENT	Time in seconds from the beginning of the simulation, indicating when the message was sent.
8	ACKD_MSG	Flag for message acknowledgment requirement.
9	MSG_TYPE	Type of message being received.
10	DNS	Domain name server.
11	QUERY	Not used.
12	NUM_DTNS	Number of destinations.
13	DTN TYPE	Destination type (action or info).
14	DTN IP	Destination IP address.
Ip_Mcast_Membership.txt		
1	MCG	Multicast group IP.
2	Num_Registered_Hosts	Number of MCG members.
3	IP_CMRP_ID_LIST	Start of listing.
4	ID	Unique identifier to each IP.
5	NET	Subnet number.
6	Radio	Radio ID number.
7	OOTE	Organization/organization type establishment ID.
8	Host_IP	Host IP address.

Column	Data Element	Definition
sa_rx_list.txt		
1	Rcvd_by	Received by IP
2	Source	Source IP.
3	Time	Time of receipt, in seconds.
4	ON	Transport radio system used.
5	K5-1#	Number of situational awareness (SA) messages this source generated, starting at 0.
6	Size	Size of message, in bits.
7	Net	Network being transmitted on.
8	SA#	Unique message ID.
9	Stat	Status of message.
10	Delay	Delay of received message, in seconds.
SA_Tx_Friendly_Report.txt		
1	OPFAC	OPFAC identifier.
2	Rank-0	Echelon indicator.
3	Rank-1	Echelon indicator.
4	EPLRS	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
5	SRW	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
6	WNW	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
7	NDL	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
8	HNW	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
9	KASAT	Does this waveform exist in the indicated OPFAC? Binary 1 for yes, 0 for no.
sa_tx_list.txt		
1	Fwd_by	Source or gateway of the source IP.
2	Time	Time transmitted, in seconds.
3	Source	Source IP.
4	Time	Time transmitted, in seconds.
5	ON	Transport radio system used.
6	K5_1#	Number of SA messages generated by this source starting at 0.
7	Size	Size of message, in bits.
8	Net	Network being transmitted on.
9	SA#	Unique message ID.

Column	Data Element	Definition
tls_output.txt		
1	sim_time	The time of the entry
2	obj_id	The OPNET object of the process. There is not yet a cross reference for lookup of obj_id.
3	entry_id	The OPFAC ID until an obj_id cross-reference is provided.
4	entry_code	Always 1 (send to lower layer). The destination protocol (TCP, UDP, MDP).
5	equip_id	The destination protocol (TCP, UDP, MDP).
6	intf_in_id	The suggested protocol (TCP, UDP).
7	major_port_id	Always port zero (0) for the host.
8	minor_port_id	Always port zero (0) for the host.
9	packet_id	The OPNET packet id of the packet containing the data for this message.
10	msg_id	The ID of the message within the generator context.
11	gen_id	The ID of the generator (0=stat; 1=script; 2=thread; 3=ma; 4=voip; 5=dns; 10=SaSystem; 11=SaPosition; 12=SaEntity).
12	retry_id	The count of retries with 0 being original message
13	packet_size	The data size of the message.
14	packet_payload	The same as packet_size, since no header overhead is added yet.
15	source_ip	The IP address of the host containing the generator
16	dest_ip	The IP address to be stamped onto the IP datagram.
result_0000_wnwlog.out (Radio state summary from time: x to time: x+m)		
1.0	Region Formation Parameters	
1.1	NetworkID	Integer.
1.2	Advanced Node Region	Integer.
1.3	Maximum Nodes per Region	Integer.
1.4	Minimum Nodes per Region	Integer.
1.5	Number of Regions	Integer.
1.6	Minimum Hops Between RAPs	Integer.
1.7	Maximum Hops Between RAPs	Integer.
1.8	Gateway Ratio	Integer.
2.0	Region Gateway Links	
3.0	Region Partition Sizes	

Column	Data Element	Definition
result_0000_wnwlog.out (Radio state summary from time: x to time: x+m) (continued)		
3.1	Radio 1	Is in region partition 1 of size 16.
4.0	Radio Specific Information	
4.1	Radio	Integer.
4.2	Net	Integer.
4.3	Region	Integer.
4.4	Routes	Integer.
4.5	Total Packets	Integer.
4.6	Total Drops	Integer.
4.7	Queue Drops	Integer.
4.8	Route Drops	Integer.
4.9	Channel Drops	Integer.
4.10	Nodes Not Ready	Integer.
4.11	Drops	Integer.

Table D-2 concluded.

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Appendix E. References

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Appendix F. Glossary

ADCON	administrative control
AGL	above ground level
AIMD	Architecture Integration Management Division
AMSAA	Army Materiel Systems Analysis Activity
ASA/ALT	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
AV	all view
AWARS	Advanced Warfighting Simulation
BCBL-G	Battle Command Battle Lab – Fort Gordon
BCT	brigade combat team
BFT	Blue Force Tracker
BGP	border gateway protocol
C2	command and control
CERDEC	Communications-Electronics Research Development and Engineering Center
CNAC	Cisco Network Admission Control
CNR	combat net radio
COCOM	combatant command
CoE	center of excellence
COMBATXXI	Combined Arms Analysis Tool for the 21st Century; also seen as CBTXXI
CoP	community of practice
CSS	combat service support
dB	decibel
DIV	data and information viewpoint
DNS	domain name server
DOD	Department of Defense
DODAF	Department of Defense Architecture Framework
EPLRS	Enhanced Position Location Reporting System
FKSM	Fort Knox Supplemental Material
FM	field manual
GCC	geocentric coordinates
GDC	geodetic coordinates
GIG	global information grid
HBCT	heavy brigade combat team
HNW	Highband Networking Waveform
HQDA	Headquarters, Department of the Army

ID	identification
IER	information exchange requirement
IP	internet protocol
ISR	intelligence, surveillance, and reconnaissance
JFC	joint force commander
JNAT	Joint Network Analysis Tool
JNN	joint network node
JP	joint publication
JTF	joint task force
kbps	kilobytes per second
LOS	line of sight
M&S	models and simulations
MALSR	mobile abstracted link state routing
MANET	Mobile Ad-hoc Network
MC CoE	Mission Command Center of Excellence
MCG	multi-cast group
MDP	message dissemination protocol
MEF	Marine Expeditionary Force
MI	military intelligence
MSG	message
MSL	mean sea level
MTOE	modified table of organization and equipment
NATO	North Atlantic Treaty Organization
NCW	Net-centric Waveform
ODCA	Operational Data Collection and Analysis
OOTE	organization/organization type establishment
OPCON	operational control
OPFAC	operational facility
OPNET	a commercial high-resolution network analysis simulation tool
OSPF	open shortest path first
OV	operational view
PEO-I	Program Executive Office - Information
PIM-DM	protocol independent multicast - dense mode
PIM-SM	protocol independent multicast - sparse mode
PM	project manager
RAP	route access protocol
RF	radio frequency

RFC	request for comments
ROSPF	radio open shortest path first
Rx	receive
SA	situational awareness
SA	situational awareness
SINCGARS	Single Channel Ground and Airborne Radio System
SME	subject matter expert
SNR	signal-to-noise ratio
SRC	standard requirements code
SRW	Soldier Radio Waveform
TACON	tactical control
TCM	TRADOC capability manager
TCP	transmission control protocol
TGEN	Traffic Generation Tool
TOC	tactical operations center
TOE	table of organization and equipment
TRAC	Training and Doctrine Command Analysis Center
TRADOC	Training and Doctrine Command
Tx	transmit
UDP	user datagram protocol
UOL	unified offered load
UTM	universal transverse mercator
V	version
VOIP	voice over Internet protocol.
WIN-T	Warfighter Information Network - Tactical
WNW	Wideband Network Waveform
WTN	warfighter tactical network

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